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ABSTRACT

This study explores the utility of the theory of planned behavior for understanding and predicting the behavioral intentions of secondary science students. Data were collected from secondary science students enrolling in earth science (8th grade), biology (9th grade), physical science (10th grade), or chemistry (11th grade). Cause-effect relations were analyzed using the method of path analysis to test the direct effects of model variables specified in the theory of planned behavior. Results indicated that students' intention to enroll in a high school physics course was determined by their attitude toward enrollment and their degree of perceived behavioral control. Attitude, subjective norm, and perceived behavioral control were formed as a result of specific beliefs students held about enrolling in physics. Grade level and career goals were found to be instrumental in shaping student attitudes. Immediate family members were identified as major referents in the social support system for enrolling in physics. Course and extra-curricular conflicts and the fear of failure were shown to be the primary beliefs obstructing students' perception of control over physics enrollment. (Author/YP)

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Attitude and Secondary School Science Students'

Intention to Enroll in Physics:

An Application of the Theory of Planned Behavior

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ABSTRACT

The purpose of this study was to explore the utility of the theory of planned behavior for understanding and predicting the behavioral intentions of secondary science students. In particular, the study used a three-stage causal model to investigate the links from external variables to behavioral, normative, and control beliefs; from beliefs to attitudes, subjective norm, and perceived behavioral control; and from attitudes, subjective norm, and perceived behavioral control to behavioral intentions.

Subjects for the study included 264 students (grades 8-12) enrolled in secondary science courses. Data were collected from secondary science students residing in the metropolitan community of a central Texas city and enrolled in earth science (8th grade), biology (9th grade), physical science (10th grade), or chemistry (11th grade). Cause-effect relations were analyzed using the method of path analysis to test the direct effects of model variables specified in the theory of planned behavior.

Results of this study indicated that students' intention to enroll in a high school physics course, the target behavior, was determined by their attitude toward enrollment and their degree of perceived behavioral control. Attitude, subjective norm, and perceived behavioral control were in turn formed as a result of specific beliefs students held about enrolling in physics. Grade level and career goals were found to be instrumental in shaping students attitude. Immediate family members were identified as major referents in the social support system for enrolling in physics. Course and extra-curricular conflicts and the fear of failure were shown to be the primary beliefs obstructing students' perception of control over physics enrollment.

The Study of Physics

Interest among students in the United States in the study of physics appears to be lowest of all the available, introductory level, high school science courses. Surprisingly some schools don't offer physics courses. Data collected by the National Science Teachers' Association revealed that 7100 high schools offered no physics courses in the 1985-86 school year (Aldridge, 1987), about 18% of all high schools according to a separate study conducted by Weiss (1987). For the 1986-87 school year the American Institute of Physics (AIP) also reported that 18% of the high schools in the United States rarely or never teach physics (Neuschatz & Covalt, 1988).

Where available the physics course typically caps the high school science offerings, but few students persist in science long enough to enroll. According to results of the High School and Beyond survey (National Center for Education Statistics, 1984) physics enrollment rates range from 19% among students living in the New England States to 6% in the West South Central States and from 27% among Asian students to 5% among Hispanics. Moreover, nearly twice as many males enroll in physics as do females (15% and 8%, respectively).

An understanding of physics appears to be lacking among the general public and also among high school physics students, which may severely limit the size of the science and engineering talent pool and further restrict the opportunities of many students to pursue careers in these fields. According to a survey of American adults 18 years of age and older performed in 1988 for the National Science Board (NSB, 1989, p. 166), only 15% of the adults can correctly answer all of seven simple questions on physics and earth science, ranging from the very simple (whether hot air rises) to the more technical (how a laser works). Moreover, international comparisons reveal the average achievement of first year high school physics students to be about 34%, below their counterparts in Japan (59%),

England (58%), and nine other countries (51%) (Jacobson, Doran, Chang, Humrich, & Keeves, 1987).

Participation and achievement in physics tends to separate science and engineering students from their nonscience peers. Immigrants to the college science and engineering pipeline are more likely to have taken physics than their nonscience peers (26% and 11%, respectively) and subsequently record higher GPAs in mathematics and science courses (Office of Technology Assessment, 1988).

Purpose

The purpose of this study was to explore the utility of the Theory of Planned Behavior for understanding and predicting the physics course enrollment intentions of secondary school science students. In particular, the study investigated the relationships between attitudes, social support, and perceived control on the behavioral intentions of 264 science students (grades 8-11) to enroll in a high school physics course prior to graduation, the target behavior of interest.

Theoretical Base

The conceptual framework for this study has its roots in the theory of reasoned action and the subsequent extension of the original constructs with the formulation of the theory of planned behavior. The theory of reasoned action was posited to explain the diversity in human behavior and attribute its causes to two independent sources, a personal and a social motivator, as mediated by behavioral intention. The theory of planned behavior extends the range of applicability of the original reasoned action model by introducing a third, independent antecedent of behavior, perceived behavioral control. The addition of this third variable permits prediction and explanation of behavior in situations in which humans have incomplete control over performance of the behavior of interest. In its revised form the theory of planned behavior is a general model in which the theory of reasoned action represents a special case.

Theory of Reasoned Action

Fishbein and Ajzen (1975) proposed the theory of reasoned action as a unifying and systematic conceptual framework that could be applied to the diverse literature on attitudes and could be used to understand a myriad of human behaviors. The theory rests on the assumption that humans are rational, have control over their behavior, and seek out, utilize, and process all available information about pending decisions before taking action. Behaviors of interest are single actions rather than behavioral categories. In contrast to single actions, behavioral categories represent inferences made from a set of behaviors, which may be relatively narrow or quite broad. Pursuing a career in science or engineering, for example, represents a broad set of behaviors, some of which might include enrolling in advanced, elective high school courses in Algebra 2, calculus, chemistry, physics; earning grades of "A" or "B" in mathematics and science courses; or entering projects in science fairs and mathematics tournaments. Observation of any one of the multitude of related single acts comprising this or any behavioral set provides an inadequate measure of a broad behavior and would be expected to be weakly associated with the behavioral category.

The theory of reasoned action presents a conceptual framework for linking behavior to specific antecedent variables — personal beliefs, attitudes, social support, and intentions. The model can be used to predict intention at any level of specificity from information on personal and normative components, provided there is correspondence between the level of specificity of predictors and criterion variables. The theoretical structure linking behavior (B), behavioral intention (BI), attitude toward the behavior (AB), subjective norm (SN), and beliefs is causal and unidirectional (Fishbein and Ajzen, 1975). Beliefs an individual holds about the consequences of engaging in a specific behavior, a within-subject effect or personal norm, lead to the formation of an attitude toward engaging in the behavior. Beliefs an individual holds about social support for engaging in the behavior, a between-subject and

referent effect or social norm, shape the subjective norm. Persons form anticipations about the likelihood of specific, personal consequences associated with engaging in a behavior (personal beliefs, b_i) and combine them with evaluative reactions toward the consequences (outcome evaluations, e_i) to form a generalized, personal judgement which is the antecedent of one's attitude toward the behavior. Similarly, individuals judge the extent to which salient referents hold expectations about performing the behavior in question (normative beliefs, $(nb)_k$) and combine these normative beliefs with their motivation to comply ($(mc)_k$) with the referents' expectancies to form a generalized social judgement, the antecedent in the reasoned action model of the subjective norm. Personal beliefs are linked with outcome evaluations and normative beliefs with motivation to comply through the expectancy value theorem. This linkage is representative of the thinking process that takes place prior to decision-making. The constructs comprising the theory of reasoned action are summarized in the following equation:

$$B \sim BI = w_1AB + w_2SN \text{ (Equation 1),}$$

where the antecedents of AB and SN are $\sum_i b_i e_i$ and $\sum_k (nb)_k (mc)_k$, respectively.

The exact nature of the information mapping process is idiosyncratic. Differences in the inter-subject expectancy and value assigned to specific beliefs give rise to differences in personal attitude and subjective norm. Inter-subject differences also may lead to variations in the relative weights assigned to personal and subjective norms. Inter-subject differences, called external variables, mediate behavior only to the extent that they give rise to differences in the salient beliefs, belief strength, outcome evaluations, normative beliefs, motivation to comply, or the relative contributions of antecedent variables to the prediction of intentions (Ajzen & Fishbein, 1980, p. 83). Crawley and Coe (in press) have shown that among grade 8 science students the relative contributions of attitude and subjective norm components (i.e., the w 's in equation 1) to the prediction of intention to enroll in a science course in grade 9 vary depending on students' gender, ethnicity, general

ability, and science ability. Thus, similar intentions may arise as a result of quite dissimilar levels of importance assigned to the antecedent variables, attitude and subjective norm, and/or differences in underlying beliefs. Evidence for the multidimensional, multiplicative nature of expectancies and the recursive nature of the theoretical constructs comprising the theory of reasoned action have been tested and substantiated by Bagozzi (1982).

The theory of reasoned action has been found to be extremely successful in explaining volitional behaviors. Volitional behaviors are those actions that do not require skill, abilities, opportunities, and the cooperation of others to perform; they require only that the individual possess the motivation to perform the behaviors, i.e., behavioral intention. The model variables have accounted for a multitude of diverse human behaviors such as drinking, dieting, choosing a career, planning a family, voting, and consumer purchasing (Ajzen & Fishbein, 1980). In educational contexts, the theory has been used successfully to understand and predict the intentions of students in New Zealand high schools to study science (Stead, 1985), grade 8 students' intentions to enroll in a high school science course (Crawley & Coe, in press), preservice elementary teachers intentions to teach science using hands-on activities (Koballa, 1986), girls' intentions to enroll in at least one physical science course in high school (Koballa, 1988), physical science teachers' intentions to use investigative teaching methods (Crawley, 1988), and grade 5-8 students' intentions to smoke (Norman & Tedeschi, 1989).

Theory of Planned Behavior

The theory of reasoned action has been criticized because of its limited applicability. Most behavior, according to Liska (1984), is neither volitional nor involitional, but ranges from behavior which requires little skill and social cooperation to behavior which requires considerable skill, considerable social cooperation or both. The theory of planned behavior was proposed by Ajzen (1985, 1988) as an extension of the theory of reasoned action to

account for the performance of behaviors that are not completely under the subject's control. The utility of the theory of reasoned action in explaining behavioral intention and subsequent behavior was found to be insufficient when subjects perceived that their control over behavioral performance was incomplete. When subjects did not possess the requisite personal attributes, resources, or opportunities to engage in the behavior in question the theory of reasoned action was an incomplete model for understanding and predicting behavior.

The theory of planned behavior adds the measure, perceived behavioral control (PBC) as "the person's belief as to how easy or difficult performance of the behavior is likely to be" (Ajzen & Madden, 1985, p. 457). A causal chain is proposed from beliefs through the intermediate variables attitude toward the behavior, subjective norm, and perceived behavioral control to behavioral intention to behavior. As in the theory of reasoned action intentions occupy a central role. Intentions "... capture the motivational factors that impact on a behavior; they are indications of how hard people are willing to try, of how much an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1989, p. 250).

Five constructs are central to the theory of planned behavior: target behavior, behavioral intention, attitude toward the behavior, subjective norm, and perceived behavioral control. The best predictor of behavior (B), according to the theory, is intention to engage in the behavior. In turn, behavioral intention (BI) is determined by three variables, one personal, one social, and one opportunistic. Attitude toward the behavior (AB), the personal component, represents the extent to which an individual believes that performing the behavior will lead to desirable consequences. Subjective norm (SN), the social component, is a measure of the extent to which an individual believes that important "others" think the behavior should be performed. Perceived behavioral control (PBC), the opportunistic dimension, represents the individual's assessment of the presence or absence

of resources and opportunities that will influence his/her ability to perform the behavior, that is, the perceived likelihood of behavioral goal achievement. The antecedent of PBC are control beliefs (cb), factors that facilitate or inhibit performance of the behavior. The sum of the control beliefs (cb) serve as a generalized judgement of personal control, which forms the individual's perceived behavioral control. The model variables comprising the theory of planned behavior are summarized in the following equation:

$$B \sim BI = w_1AB + w_2SN + w_3PBC \text{ (Equation 2),}$$

where $\sum_i b_i a_i$, $\sum_k (nb)_k (mc)_k$, and $\sum_n (cb)_n$ are the antecedents of AB, SN, and PBC respectively.

The theory of planned behavior has been used to successfully predict college students' attendance at class lectures and getting a grade of "A" in a course (Ajzen & Madden, 1985) and weight loss over a 6-week period among college women (Schifter & Ajzen, 1985). For situations in which perceived behavioral control does not pertain or is irrelevant, the theory of planned behavior conceptually and empirically reduces to the theory of reasoned action (Ajzen and Madden, 1986 p. 460; Ajzen, 1985).

In education, the theory of planned behavior has been successfully used in studying the intentions of science teachers to use investigative teaching methods (Crawley, in press). Simple regression analyses revealed that attitude, subjective norm, and perceived behavioral control accounted for 28% ($p = .0007$) of the variance in intentions of science teachers to use investigative teaching methods. The explanatory power of the theory of planned behavior was not improved when a hierarchical model (independent plus interaction effects) was compared with a simple model (independent effects only). Furthermore, the increase in the explained variance in the intentions of science teachers gained as a result of adding perceived behavioral control to the antecedent variables proved to be insignificant, thereby reducing the theory of planned behavior to the theory of reasoned action.

Method

Subjects

Participants in this study were secondary science students ($n = 264$) residing in the metropolitan community of a central Texas city who were enrolled in one of four courses: earth science (offered in grade 8, required), biology (offered in grade 9, required), physical science (offered in grade 10, required) or chemistry 1 (offered in grade 11, elective). All students in grade 8 are enrolled in earth science. Most students complete biology in grade 9 and physical science (1 semester each of introductory physics and chemistry) in grade 10. It is possible, however, to substitute a geology course for physical science in grade 10. Students who elect to enroll in Chemistry 1 are primarily college bound.

During the time of the study students were enrolled in grade 8 ($n = 45$), grade 9 ($n = 98$), grade 10 ($n = 84$), or grade 11 ($n = 37$), with about equal numbers of males ($n = 119$) and females ($n = 142$). Nearly 60% of the students were white ($n = 152$), but significant numbers of Hispanic ($n = 76$), Black ($n = 25$), Oriental ($n = 5$), and other ($n = 2$) were represented. Nearly 80% of the students planned to graduate from college ($n = 209$), but some indicated that they planned to attend college for a while ($n = 13$), complete high school and go to technical school ($n = 19$), complete high school then work full time ($n = 18$), or leave high school to work full time ($n = 3$). Students were asked to select their career goals from among options of either a service or professional nature. Slightly more than 15% of the students indicated that they planned to enter service jobs, either nonscience-related ($n = 26$), science-related ($n = 3$), or physics-related ($n = 11$). The remainder of the students were interested in pursuing either nonscience ($n = 105$), science-related ($n = 83$), or physics-related professional jobs ($n = 18$).

Variables

Variables selected for examination in this study were those specified in the theory of planned behavior and were of two basic types, exogenous and endogenous. Exogenous variables consisted of grade level, gender, ethnicity, educational goal, and career goal and represented variables whose differences lay outside the realm of the theory of planned behavior to explain (external variables). Inclusion of gender, ethnicity, educational and career goals in the study is justified on the basis of past research which has documented the association of these variables with the endogenous variables (attitude, subjective norm, perceived behavioral control, and intention). The addition of the grade level as an exogenous variable permits prediction of behavioral intention among students for whom "physics enrollment" represents a proximal behavior (11th graders) through the grade levels to students for whom the outcome represents a relatively distal behavior (8th graders).

Endogenous variables represent variables accounted for in the causal model posited in the theory of planned behavior. Seven endogenous variables were included in this study: attitude and its antecedent beliefs, subjective norm and its antecedent beliefs, perceived behavioral control and its antecedent beliefs, and behavioral intention.

The target behavior presented to students in this study was "enrolling in a physics course in high school before graduation". The behavior is specific and contains the four, essential components — action (enroll in), target (physics course), context (in high school), and time (before graduation) — as specified by Ajzen and Fishbein (1980). To save space and reading time students were told that the statement would be shortened to read "enrolling in a high school physics course", with the implied time component, "before graduation".

Questionnaire Design

A representative sample of students provided information on their behavioral beliefs, normative beliefs, and control beliefs in a pilot study. An open-ended questionnaire was

administered in the pilot study, following the procedures detailed by Ajzen and Fishbein (1980, p. 261). Students were asked to list the advantages and disadvantages of enrolling in physics in high school (behavioral beliefs), the persons who would be concerned about their course selection (normative beliefs) and some of the problems or situations that might arise that would facilitate or inhibit their enrolling in physics (control beliefs).

Belief data were content analyzed to arrive at modal salient beliefs, accounting for 90% of the beliefs identified on the open-ended questionnaire. Seven personal beliefs, five normative beliefs, and seven control beliefs about engaging in the target behavior were identified during the pilot study.

The final questionnaire contained items that provided information on each of the five exogenous and seven endogenous variables. Behavioral intention was measured using a 7-point, bipolar adjective scale, anchored by the adjectives "unlikely" and "likely". A direct measure of attitude toward the behavior was obtained by summing subjects' responses to each of four, 7-point, bipolar, evaluative adjective pairs. Indirect or expectancy-value measures of attitude were obtained by summing the products of behavioral belief and the corresponding evaluation of outcome statements, for each of the seven beliefs. In a similar manner, direct and indirect measures of subjective norm were measured. Perceived behavior control was measured using one direct item and the sum of scores to seven control belief items.

Data Analysis

A three-stage causal modeling methodology was used to test the tenability of the theoretical assumptions underlying the theory of planned behavior. The method of path analysis was employed to test the direct effects of exogenous variables (grade level, gender, ethnicity, educational goal, and career goal) on endogenous variables (behavioral, normative, and control beliefs) and endogenous variables on endogenous variables (variations in attitude, subjective norm, and perceived behavioral control caused by beliefs

and variations in behavioral intention caused by attitude toward the behavior, subjective norm, and perceived behavioral control), to the extent the causal relations are hypothesized in the planned behavior model. No attempt was made, therefore, to analyze and explain any of the interrelationships that might exist among the five exogenous variables, among students' beliefs (behavioral, normative, control), or interactions. The recursive nature of the model variables in the theory of planned behavior is depicted in the path diagram and causal relations found in Figure 1.

Insert Figure 1 about here

Theory trimming was employed with exogenous and endogenous variables (Pedhazur, 1982, p. 616-617). The decision is justified on theoretical and educational grounds. The theory of planned behavior does not specify the exact nature of the relationship between specific external variables and beliefs, only that inter-personal differences give rise to differences in beliefs (Ajzen & Fishbein, 1980, p. 82-83). Moreover, trimming variables making nonsignificant contributions to model effects at this stage of analysis permits exploration of the underlying causes of differences in students' beliefs and in the motivational bases related to their intention to enroll in a high school physics course.

Results

Content analysis of students' responses to the open-ended questionnaire yielded seven salient behavioral beliefs, five personal referents, and seven control beliefs. Consequences of "enrolling in physics" identified by students included attained educational and/or career goals, increased knowledge of physics, more work at home and in school, learning useful information, helping the grade point average, and studying interesting topics. Parents/guardians, brothers/sisters, current science teacher, friends, and the counselor were identified as personal referents associated with students' decision to enroll in physics.

Control factors that might prevent physics enrollment included conflict with another course, hearing that physics is hard or boring, dislike of the physics teacher, reduced study time due to after-school activities, a fear of failure, and a change in career or educational plans. No facilitating factors were reported on the open-ended questionnaire.

Results of administering the final questionnaire produced scores that varied throughout the allowable score range for all variables except the expectancy-value attitude ($\sum e_i b_i$). The consequences of and social support for enrolling in physics were favorable, as was evidenced by the positive values of the expectancy-value attitude and expectancy-value subjective norm ($\sum_k n b_k m c_k$). The sum of the control beliefs revealed that students were unlikely to be deterred from enrolling in physics by factors outside of their control. Results of direct measures of attitude (AB), subjective norm (SN), and perceived behavioral control (PBC) mirrored those of the indirect measures obtained from the belief data. Behavioral intention, on average, indicated that students were slightly likely to enroll in physics. Descriptive results for model variables are presented in Table 1.

Insert Table 1 about here

Computation of the intercorrelations existing among model variables resulted in significant values for half of the 28 combinations. Pearson product-moment correlations ranged in value from a high of .71 ($p = .0001$) for the attitude-behavioral intention interaction to a low of .00 ($p = .9766$) for the normative belief-behavioral intention interaction. The matrix of intercorrelations and levels of significance is presented in Table 2.

Insert Table 2 about here

In stage 1 of the analysis the five external variables were treated as causes of belief formation. Path coefficients were determined for the regression of behavioral, normative, and control beliefs on the exogenous variable set. Significant path coefficients were computed for the influence of grade level and career goal on the formation of behavioral beliefs. Ethnicity proved to be the sole cause of differences in students' normative beliefs. Differences in students' control beliefs were found to be attributable to differences in educational goals. Path coefficients produced as a result of the first stage of analysis are presented in Table 3.

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Insert Table 3 about here
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The influence of beliefs on the formation of students' attitude, subjective norm, and perceived behavioral control was examined in the stage 2 analysis. Students' attitude toward enrolling in a high school physics course was found to depend upon the extent to which they perceived that enrollment would help them attain educational and career goals, increase their knowledge, learn useful information, improve their grade point average, and study interesting topics. The possibility of taking on an increased work load proved to be unrelated to students' attitude. Results of the stage 2 analysis are found in Table 4.

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Insert Table 4 about here
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In the third and final stage of the analysis attitude, subjective norm, and perceived behavioral control were treated as motivational bases for the formation of behavioral intentions. Students' attitude and perceived behavioral control were found to be the sole causes of differences in behavioral intentions, with path coefficients of .60 and .22, respectively. Subjective norm was found to be unrelated to students' behavioral intentions

($\beta = -.04$, $p = .3824$). The relative contributions of attitude, subjective norm, and perceived behavioral control to the formation of behavioral intentions are found in Table 5.

Insert Table 5 about here

Trimming reduced the number of exogenous and endogenous variables included in the final path diagram. Differences in behavioral beliefs were found to arise out of differences in students' grade level and career goals and accounted for 13% of the overall variance in beliefs. Beliefs about support from significant referents varied depending on students' ethnicity but explained only 1% of the variance in normative beliefs. Moreover, differences in students' educational goals were shown to affect their control beliefs, but accounted for only 1% of the variance in beliefs. Six behavioral beliefs about the consequences of enrolling in physics were identified as instrumental in the formation of attitude toward the behavior. Beliefs about attaining educational and career goals, increasing one's knowledge, learning useful information, helping the grade point average, and studying interesting topics shaped students' attitude (explaining 50% of the variance), which in turn affected students' behavioral intention. Members of the immediate family (parents/guardians and brothers/sisters) impacted students' subjective norm (accounting for 22% of the variance), but subjective norm proved to be unrelated to students' behavioral intentions. Conflict with another course, reduced study time due to extra-curricular activities, and a fear of failure were beliefs that influenced students' perception of personal control, explaining 5% of the variance and impacting their behavioral intentions. Attitude and perceived behavioral control were the sole determinants of behavioral intention. Path coefficients, significance level, and explained variance for the trimmed model are summarized in Table 6.

Insert Table 6 about here

Discussion

The theory of planned behavior provided the theoretical basis for examination of secondary school students' intentions to enroll in a physics course prior to high school graduation. Data were analyzed to arrive at the relative contributions of exogenous and endogenous model variables to the prediction of behavioral intention using the methods of path analysis and theory trimming. Exogenous variables were examined to determine which, if any, were instrumental in the formation of personal, social, or environmental beliefs, which in turn were examined to arrive at determinants of attitude, subjective norm, and perceived behavioral control, respectively. Results of the three-stage analysis and subsequent theory trimming are depicted in Figure 2.

Insert Figure 2 about here

Results of this study reveal that beliefs about the consequences of enrolling in physics are formed in the early secondary school years. Unfortunately, beliefs tend to be less favorable the farther along students progress in school. Professional and scientific career goals, on the other hand, influence the formation of beliefs supportive of enrolling in physics. This result suggests that science teachers should encourage students to pursue science-related and in particular physics-related professional careers early in the secondary school years which in turn may result in a greater commitment to the study of physics in high school.

Unsuspected was the finding that subjective norm proved to be unrelated to students' behavioral intentions. Members of students' immediate family provide the source of social

support for enrolling in physics, but this support appears not to be instrumental in the formation of intention. The insignificant contribution of this key model variable to enrollment intentions may result from a grade level effect. Students in grade 8-10 are enrolled in science courses required for high school graduation. Parents may not support and encouragement (and exert pressure on) their sons/daughters to enroll in physics, an elective science course, until they near the end of the required secondary science program sequence and face decisions concerning careers and post-secondary school education.

Enrolling in physics may prove to be difficult for some students, regardless of their personal interest or the social support they receive. Conflicts with other courses required for graduation and reduced study time due to involvement in extra-curricular activities present realistic obstacles to enrolling in physics and must be addressed. Before more students can be attracted to physics these barriers to enrollment must be resolved by students and their families in concert with the school. Moreover, students' fear of failure, this study shows, presents an additional obstacle outside of their control. To assuage the fear of failure, well-founded or not, may require the cooperative efforts of schools, teachers, and parents if physics course enrollments are to be improved.

Results of this study provide support for use of the theory of planned behavior by science educators interested in undertaking experiments designed to increase student enrollment in elective science courses and thus increase the size of the talent pool in the science and engineering professions. Information about the favorable consequences of enrolling in physics, for example, can be increased and intensified through the use of systematically planned interventions designed to improve students' attitude toward this target behavior. Immediate family members offer another potential source of social influence to support and encourage their sons/daughters to enroll in physics. Future researchers might examine the elaboration-likelihood model proposed by Petty and Cacioppo (1986), which provides a theoretical basis for altering personal and social beliefs.

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Table 1

Descriptive Results for Endogenous Variables

Outcome	Mean	SD	Actual Range	Possible Range
$\Sigma_{1-7}b_i\theta_i$	12.03	21.63	105	-63 to +63
$\Sigma_{1-5}(nb)_k(mc)_k$	6.53	14.25	90	-45 to +45
$\Sigma_{1-7}(cb)_n$	-1.59	9.61	42	-21 to +21
AB	2.90	5.34	24	-12 to +12
SN	1.60	4.08	18	-9 to +9
PBC	5.20	1.78	6	+1 to 7
BI	0.39	2.05	6	-3 to +3

Table 2

Variable Correlation and Significance Level Matrix

	EV	BB	NB	CB	AB	SN	PBC
BB	.38 (.0001)						
NB	.17 (.2466)	.01 (.8684)					
CB	.17 (.2594)	.33 (.0001)	.09 (.1220)				
AB	.38 (.0001)	.68 (.0001)	.01 (.8498)	.22 (.0004)			
SN	.11 (.7018)	.06 (.3566)	.36 (.0001)	.10 (.1035)	.10 (.0963)		
PBC	.33 (.0001)	.36 (.0001)	.05 (.4502)	.04 (.5235)	.43 (.0001)	.01 (.8333)	
BI	.36 (.0001)	.56 (.0001)	.00 (.9766)	.27 (.0001)	.71 (.0001)	.10 (.0998)	.48 (.0001)

Note. Sample size ranged from 238 to 264 for computation of correlations.

Table 3

Summary of Path Coefficients — Stage 1

Effect	Cause	Beta	Std. Error	p
Behavioral beliefs	Grade Level	-.12	1.42	.0444
	Gender	-.05	2.66	.3836
	Ethnicity	.07	1.39	.2839
	Educational goal	.05	1.43	.4771
	Career goal	.35	1.08	.0001
Normative beliefs	Grade level	.03	0.97	.6556
	Gender	.05	1.81	.4248
	Ethnicity	-.15	0.95	.0252
	Educational goal	-.10	0.98	.1560
	Career goal	.00	0.74	.9612
Control Beliefs	Grade level	.04	0.65	.5440
	Gender	.01	1.23	.9339
	Ethnicity	-.02	0.64	.7136
	Educational goal	-.15	0.66	.0329
	Career goal	.12	0.50	.0847

Table 4

Summary of Path Coefficients — Stage 2

Effect	Cause	Beta	Std. Error	p
Attitude	Attain educational goals	.22	0.07	.0015
	Attain career goals	.20	0.06	.0028
	Increased knowledge	.16	0.08	.0027
	More work to do	-.04	0.06	.4018
	Learn useful information	.16	0.07	.0034
	Help grade point average	.10	0.05	.0389
	Study interesting topics	.17	0.07	.0038
Subjective Norm	Parents/guardians	.39	0.07	.0001
	Brothers/sisters	.21	0.07	.0033
	Science Teacher	-.06	0.07	.3734
	Friends	.01	0.08	.8487
	Counselor	-.06	0.08	.3805
Perceived Behavioral				
Control	Course conflict	-.18	0.06	.0104
	Hearing physics is hard	.03	0.09	.7199
	Hearing physics is boring	.12	0.08	.1982
	Extra-curricula conflicts	-.18	0.08	.0355
	Fear of failure	.27	0.07	.0024
	Dislike of the teacher	-.02	0.06	.7764
	Change in career/ed. plans	-.06	0.08	.4251

Table 5

Summary of Path Coefficients — Stage 3

Effect	Cause	Beta	Std. Error	p
Behavioral Intention	Attitude	.60	0.02	.0001
	Subjective Norm	-.04	0.02	.3824
	Perceived Behavioral			
	Control	.22	0.05	.0001

Table 6

Summary of Path Coefficients — Trimmed Model

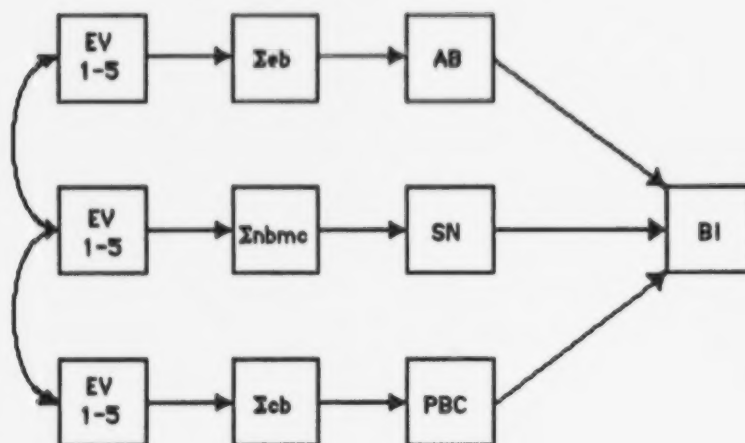
Effect	Cause	Beta	p	adjR ²
Behavioral beliefs	Grade level	-.14	.0193	—
	Career goals	.34	.0001	.13
Normative beliefs	Ethnicity	-.10	.1163	.01
Control beliefs	Educational goals	-.10	.1180	.01
Attitude toward behavior	Attain educational goals	.22	.0015	—
	Attain career goals	.20	.0029	—
	Increased knowledge	.16	.0031	—
	Learn useful information	.15	.0045	—
	Help grade point average	.09	.0480	—
	Study interesting topics	.16	.0052	.50
Subjective norm	Parents/guardians	.34	.0001	—
	Brothers/sisters	.20	.0015	.22
Perceived behavioral control	Course conflict	-.16	.0124	—
	Extra-curricula conflicts	-.15	.0613	—
	Fear of failure	.29	.0003	.05
Behavioral intention	Attitude toward behavior	.61	.0001	—
	Perceived behavioral control	.22	.0001	.53

Note. Change in effect variance resulting from trimming was insignificant.

Figure Caption

Figure 1. Path diagram and causal relations among exogenous and endogenous variables specified in the theory of planned behavior.

Path Diagram



Causal Relations

Stage 1

1. $\Sigma eb = w(EV)$
2. $\Sigma(nb)(mc) = w(EV)$
3. $\Sigma cb = w(EV)$

Stage 2

4. $AB = w\Sigma eb$
5. $SN = w\Sigma(nb)(mc)$
6. $PBC = w\Sigma cb$

Stage 3

7. $BI = tAB + uSN + vPBC$

(where w 's, t , u , and v are the relative contributions of each cause to the prediction of effects.)

Figure Caption

Figure 2. Path coefficients (and standard error) for causal relations in trimmed model of the theory of planned behavior.

